COMPENSATORY VALUE OF AN URBAN FOREST: AN APPLICATION OF THE TREE-VALUE FORMULA

by David J. Nowak

Abstract. Understanding the value of an urban forest can give decisionmakers a better foundation for urban tree management. According to the tree-valuation formula of the Council of Tree and Landscape Appraisers, the estimated compensatory value of the urban forest in Oakland, California, (21% tree cover) is $385.7 million, with residential trees accounting for 58.6% of the total value. Tree compensatory values range from $19,800/acre on institutional lands to $1,400/acre for trees on lands with transportation uses (airports, freeways, etc.). The value of trees in the area of the 1991 Oakland fire was approximately $26.5 million.

As budgets for city tree programs shrink nationwide (10), understanding the value of an urban forest can give municipalities a basis with which to develop and evaluate programs for managing urban trees. In North America, the most widely used method for estimating the compensatory value of trees is a tree-valuation formula developed by the Council of Tree and Landscape Appraisers (CTLA) (3,6). Compensatory values represent compensation for the loss of an individual tree.

Although there has been some criticism (e.g., 11) of the valuation method in the seventh and previous editions (the eighth edition with major revisions was published in August, 1992) (3), the method was formulated and approved by the CTLA representing five green-industry organizations.

The CTLA formula (7th edition) (6) was applied to an extensive sample of urban trees across the major land uses in Oakland, California, to determine the compensatory value of the urban forest in total and by land use (7). The formula also has been used to estimate the value of street tree populations (5).

This paper demonstrates that compensatory values of the urban forest vary within a city and reports the total value of Oakland's urban forest. It also shows how these values can be applied to an extensive tree loss such as that which occurred in October 1991, when a wildfire in the Oakland hills killed 26 people, destroyed 3,210 homes and apartments, and caused more than $1.5 billion in damage over approximately 1,500 acres (9).

Methods

Percent tree cover over the entire City of Oakland for 1988 was estimated using random dot grid sampling (36 dots/in^2) of black and white aerial photographs (1:12,000). Each dot was classified by census-tract area, cover type, and land use type. Percent tree cover was calculated by dividing the number of dots falling on trees in an area (e.g., census tract, land use type) by the total number of dots in the area (7). Ground sampling of 5% of Oakland's urban forest was conducted in 1989 (7,8). Species, diameter (dbh), condition and location (position in land use; e.g., front yard residential), and other information were noted for each tree sampled.

Urban tree value. A straightforward application of the CTLA tree-valuation formula was used to estimate the compensatory value of the urban forest and relative values by land use type. Four characteristics of each sampled tree were used to determine tree value based on the CTLA's tree appraisal guide (6): 1) tree basal area (trunk cross-sectional area at 4.5 feet), 2) species, 3) condition, and 4) location.

For trees less than 9 inches in diameter, replacement costs were used as the base value. The replacement cost used for a 1 inch tree was $100; 2 inch: $275; 3 inch: $450; 4 inch: $600; 5 inch: $850; 6 inch: $1,125; 7 inch: $1,425; and 8 inch: $1,650 (6). For trees larger than 8 inches in diameter, the base value was determined by multiplying the tree's basal area (in square inches) by a base dollar value of $27.00/in^2.

For palm trees, the base value was determined by a dollar value multiplied by trunk feet below live crown (6). The base dollar value is adjusted by

multiplying by species, condition, and location factors that range in value from 0 to 1.

Species factors were derived from an International Society of Arboriculture (Western Chapter) guide of species factors for trees in northern coastal California (2). Species factors were listed for poor and deep soil areas; these factors were averaged for Oakland as that city's soil is a combination of poor and deep soil areas (2). This averaging resulted in individual species factors ranging from 0.1 to 0.9.

With the inventory data available, general information on tree condition and location was used. Condition ratings were based primarily on foliage, crown, and trunk conditions; location factors were based on general land use. These general condition and location codes were considered adequate for revealing compensatory values of a large number of trees but are not appropriate for evaluating individual trees for compensatory claims. For example, over a large population, the median location factor for urban residential trees is 0.6, but suggested location factors for individual urban residential trees are between 0.3 and 0.9 (6).

Condition factors were as follows: a condition rating of excellent (full, healthy crown) = 0.9; 5-25% of crown showing dieback or leaf discoloration = 0.75; 25-50% = 0.5; 50-75% = 0.25; 75-100% = 0. Trees with trunk wounds larger than 25% of tree circumference were lowered by one condition class. Trees in wildland areas with more than 75% crown deterioration were assigned a condition value of 0.1 because of their wildlife value and relatively small hazard to humans.

Location factors were average values derived from the CTLA tree appraisal guide (6): golf = 0.8; commercial, industrial, or institutional = 0.75; residential or street tree = 0.6; managed stands or freeway = 0.4; wildland areas = 0.2.

Effect of 1991 fire on tree value in Oakland. To estimate the tree value lost due to the 1991 fire in Oakland, the average compensatory value per acre of tree cover by land use type for the entire city was applied to the number of acres of tree cover burned, by land use type, in the fire area.

Results

Oakland's trees are relatively small, with 61% less than 6 inches in diameter (Table 1). The average diameter of trees in Oakland was 6.3 inches. About 48 percent of Oakland's trees are in wildland areas compared with about 1 percent in commercial/industrial areas (Table 2). Its urban forest is dominated by blue gum (*Eucalyptus globulus*), Monterey pine (*Pinus radiata*), coast live oak (*Quercus agrifolia*) and California bay (*Umbellularia californica*) (7). These four species account for 50.7% of the total number of trees (standard error (SE) = 2.8%) and 49.1% of the

Table 1. Diameter distribution of trees (percent in each diameter class) by land use within Oakland, California (1989).

Land use	No. trees sampled	Diameter class (inches) 0-6	7-12	13-18	19-24	25-30	>30
Residential	12,937	54.8	30.7	9.8	3.8	0.7	0.1
Wildland	6,567	61.3	24.0	10.3	3.5	0.7	0.2
Institutional[1]	4,937	57.4	23.3	11.7	5.7	1.5	0.5
Transportation[2]	482	89.1	9.3	0.9	0.3	0.5	0.0
Commercial/industrial	689	62.6	29.6	6.0	1.6	0.3	0.0
Street trees[3]	1,382	63.5	28.4	7.1	0.9	0.1	0.1
City of Oakland	26,994	60.9	24.8	9.8	3.6	0.8	0.2

[1] Miscellaneous land use (88 acres, 0.7% tree cover) included with Institutional land use (park, school, golf course, cemetery, etc).
[2] Airport, shipyard, freeway, etc.
[3] Between sidewalk and curb of street.

Table 2. Tree density (trees/acre), tree cover (%) and total number of trees, by land use, within Oakland, California (1989).

Land use	No trees/acre Mean	SE[1]	% tree cover Mean	SE	No. of acres	No. of trees Total	SE
Residential	39.2	1.5	21.2	0.3	14,310	561,500	21,200
Wildland	118.3	6.2	45.9	0.5	6,500	768,000	40,200
Institutional	45.3	4.2	18.3	0.6	3,330	150,800	13,800
Transportation	13.5	3.6	3.8	0.2	4,770	64,500	17,400
Commercial/industrial	4.1	0.4	2.2	0.2	3,810	15,600	1,600
Street trees	44.1[2]	2.3[2]	0.4	0.0	620[3]	27,300	1,400
City of Oakland	48.5	1.5	21.0	0.2	32,720	1,587,700	50,600

[1] Standard error.
[2] Trees per linear mile of planted street.
[3] Linear miles of planted streets

total tree cover (SE = 2.1%).

Species-composition and species-factor distributions vary by land use type, with 22.6 percent of Oakland's trees having a rating of 0.1 (Table 3). The average species rating for Oakland's trees was 0.42; street trees had the highest species rating (0.59) while wildland trees had the lowest (0.35).

Nearly 60% of Oakland's trees were rated as excellent with a condition factor of 0.9 (Table 4); the average tree condition was rated as 0.78. Tree conditions varied by land use with transportational (e.g., freeways, airports) and residential trees rated the highest and trees on wildland areas and institutional lands rated the lowest.

Oakland's total urban forest is valued at $385.7 million, an average of $11,800/acre (Table 5). Residential trees contribute the most (58.6%) to the overall forest value. Institutional trees have the highest per-acre value ($19,800).

The estimated value of trees lost due to the 1991 fire in Oakland is $26.5 million.

Discussion

Oakland's average tree condition rating (0.78) is comparable to that found in a 1989 street tree survey of U.S. cities and towns (1). Using the same factor weighting scheme applied to Oakland's condition classes, the average condition rating for U.S. street trees is 0.71. New data from 24 cities added to the 1989 survey indicate an average street tree condition rating of 0.70 (J.J.

Table 3. Percent of trees classified within each species factor rating, by land use, within Oakland, California (1989).

Land use	Species factor rating 0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
Residential	6.1	12.3	9.6	11.4	19.2	20.1	9.2	7.0	5.1
Wildland	35.5	11.1	3.2	1.8	22.1	19.8	0.6	5.7	35.5
Institutional	27.4	8.9	4.5	3.4	17.9	20.4	4.5	7.0	6.1
Transportation	14.1	1.2	4.4	6.8	29.3	9.7	1.9	2.3	30.3
Commercial/industrial	5.2	6.7	14.4	8.0	19.3	19.3	14.7	4.7	7.7
Street trees	1.8	2.1	6.2	11.5	10.9	26.8	30.9	4.8	5.0
City of Oakland	22.6	10.7	5.8	5.8	20.7	19.7	4.7	6.1	5.8

Table 4. Percent of trees classified within each condition factor rating, by land use, within Oakland, California (1989).

Land use	Condition factor rating 0.0	0.25	0.5	0.75	0.9
Residential	1.2	2.0	6.3	22.4	68.1
Wildland[1]	4.3	2.9	9.3	31.1	52.4
Institutional	3.0	3.5	12.1	34.5	46.9
Transportation	0.8	1.0	2.9	15.8	79.5
Commercial/industrial	1.7	3.3	8.9	20.3	65.7
Street trees	2.1	3.1	13.2	30.4	51.2
City of Oakland	2.9	2.6	8.3	27.6	58.6

[1] Wildland trees with more than 75% crown deterioration were assigned a condition value of 0.1 rather than 0.0 because of their wildlife value and small hazard to humans.

Kielbaso, 1992, pers. commun.). Oakland's average tree condition is slightly higher than the national street tree average probably because of the city's large number of small trees.

In the 1989 survey, 67.2% of the street trees were less than 12 inches in diameter (1). This compares with 66.6% in the updated survey (J.J. Kielbaso, 1992, pers. commun.) and 85.7% of Oakland's trees that are less than 12 inches in diameter.

The compensatory values for Oakland likely are conservative. The base value of $27/in^2$ used in this study will likely be less than the base values derived from the most recent evaluation guide (3). In addition, the new adjusted trunk-area formula (3), which reduces the computational trunk area and, therefore, the base price of trees more than 30 inches in diameter, will have little impact on Oakland's value as only 0.2% of Oakland's trees are larger than 30 inches.

Kielbaso (4) estimated that the average value of a U.S. street tree is $525. Oakland's average tree value ($243) and average street tree value ($364) are lower than Kielbaso's estimate, again probably because of the relatively large number of small trees found in Oakland's urban forest. Even with this conservative valuation, Oakland's urban forest is valued at $385.7 million. The vast major-

Table 5. Dollar values of trees per acre, per tree, and total tree dollar value, by land use, within Oakland, California (1989).

Land use	Tree value/acre Mean	SE[1]	Value/tree Mean	SE	Tree value Total (in millions of dollars)	SE	% of total value
Residential	15,800	700	403	18	226.03	9.89	58.6
Wildland	10,900	500	92	4	70.71	3.28	18.3
Institutional	19,800	3,300	438	73	66.08	11.06	17.1
Transportation	1,400	200	103	18	6.62	1.14	1.7
Commercial/industrial	1,700	200	404	47	6.31	0.73	1.6
Street trees	15,900[2]	1,300[2]	364	30	9.94	0.82	2.6
City of Oakland	11,800	500	243	10	385.69	15.28	100.0

[1] Standard error
[2] Dollars per linear mile of planted street.

ity of Oakland's compensatory urban forest value is in trees on residential lands ($226 million), while street trees are valued at $9.9 million.

Impact of 1991 fire in Oakland. Many of the trees that survived in the burned area, as well as healthy trees outside of the burned area, likely will be removed in an attempt to reduce the potential of future fires. The actual value of trees either directly or indirectly lost due to the fire remains to be determined as the indirect effect of healthy tree removals will continue into the future. The estimated $26.5 million compensatory value assumes that all trees within the burned area will be removed. This amount is equivalent to 1.8% of the total estimated damage due to the fire (9).

Although the CTLA tree-valuation formula often is applied on a case-by-case individual tree basis, general application of this method across city land use types can provide useful data for city personnel. The 1991 Oakland fire is an excellent example of how broad application of the CTLA formula can be used to estimate compensatory tree loss following relatively large disasters. In addition, compensatory values for trees throughout the city can provide valuable information for developing and substantiating urban forestry budgets.

Conclusion

Although street trees are a valuable resource and have a high compensatory value, residential trees dominate the overall compensatory value of the urban forest with street trees comprising only 2.6% of Oakland's total compensatory value. As a result, urban forest managers must go beyond street tree issues and address tree issues on residential and other lands by enacting wise city ordinances and properly educating homeowners, non-profit groups and private organizations. Compensatory values can be used as a tool to provide justification for sound management of and fiscal support for urban trees, as well as estimating tree value loss following urban wildfires and other disasters.

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Research Forester
USDA Forest Service
Northeastern Forest Experiment Station
5801 N. Pulaski Rd., Bldg. C
Chicago, IL 60646